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Does Human Capital Cause Economic Growth? A Case Study of India

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Abstract

This study examines the time series behavior of investment in physical capital, human capital (comprising education and health) and output in a co-integration framework, taking growth of primary gross enrolment rate and a dummy for structural adjustment programme (openness which has been initiated in 1991) as exogenous variables in India from 1960 to 2006. The results suggest that physical capital investment has no long-run nor short-run effect but the human capital investment has significant long-run effect on per capita GNP; the stock of human capital measured by primary gross enrolment rate (lagged by three years) and openness is found to have a significant effect on growth of per capita GNP. The Generalized Impulse Response Function confirms that the innovation in per capita GNP growth can only explain the movements of the growth of per capita GNP (itself) and investment in education human capital positively and significantly only for a short period of time but does not explain the movements of the investment in physical capital and health human capital. Moreover, the innovation in change in education human capital investment significantly and positively explains the movement of the changes in education human capital investment (itself), health human capital investment and growth of GNP per capita; the innovation in health human capital investment significantly explains the changes of education and health human capital investment only. This study may help towards policy modeling of economic growth in India, taking into account the relevance of endogenous growth.

Keywords: Human Capital Investment, Cointegration, Economic Growth

JEL classification: C22, O47, F43

1. Introduction

Traditionally, economic theory has given emphasis on physical capital accumulation as the most robust source of economic growth, at least in the short-run, with exogenous technical progress being the long-run determinant of growth. The exogeneity of technological progress in the neoclassical growth model and the difficulty of explaining long-term economic growth (because of diminishing returns to physical capital) have restricted the analytical capacity of the neoclassical model and its empirical verification. This problem is solved by endogenous growth models developed by Romer (1986) and

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Lucas (1988) giving emphasis on human capital accumulation. Human capital theory suggests that individuals and society derive economic benefits from investments in people (Sweetland, 1996). Education has consistently been emerged as the prime human capital but Becker (1993) and Schultz (1997) have argued that health and nutritional expenditure is also a part of human capital investment. This is because education is perceived to contribute to health and nutritional improvements. Education, health, nutrition, water and sanitation complement each other, with investments in any one contributing to better outcomes in the others (World Bank, 2001b). In models of economic growth, human capital in the form of schooling or enrollment has been given a central place while the role of health has remained peripheral. Health may have been left in the periphery because neither health related data covering a long horizon nor the historical framework to study them is within the purview of mainstream macro-growth economics (Arora, 2005). The concept of human capital refers to the abilities and skills of human resources of a country, while human capital formation refers to the process of acquiring and increasing the number of people who have the skills, good health, education and experience that are critical for economic growth. Thus, investment in education and health are considered as human capital development. This paper examines the interplay between human capital and economic growth whereby human capital is understood as the sum of the investments in education and health. Although it is obvious that there are correlations between human capital and income (GNP), the interconnections between the specific parts of human capital (education and health) and GNP are of diversified nature. Education - especially in its qualitative fashion, like the number of various types of degrees or employed academic staff in the industry and less in its quantitative fashion, like schooling or enrollment numbers - is said to be an explanative variable for GNP, while health behaves in a different mode.

Investments which meet existential healthcare needs do not grasp as GNP driver in the same way as healthcare investments above this existential or 'surviving' minimum. The first ones are said to be 'strategic' long-run investments, while the second ones perform as true short-run GNP drivers. The first are growth enablers, the second growth drivers, especially in developing economies.

Given the fiscal constraints of developing countries like India, investments in social sector development mainly in health and education may be contemporaneous substitutes or complements.

Our objective is to explore the effect of both education and health human capital investment and their stocks on economic growth besides other growth influencing factors in a multivariate cointegration framework. Before formulating the theoretical model, let us first consider the important findings relating to the effects of education and health on economic growth across the countries in the world. Section 2 and section 3 outline the important review of literature on the effects of education and health on economic growth respectively. The progress of human capital investment and human capital stock is illustrated in section 4. Section 5 deals with the theoretical framework, data and estimation technique. The results of the model are given in section 6. Section 7 reports the concluding observations.

2. Education Human Capital and Economic Growth

From the early 1990s, various studies have attempted to identify the determinants of economic growth; long-run growth is endogenous rather than exogenous (Romer, 1986; Lucas, 1988; Mankiw et al. 1992). Lucas's (1988) interpretation of human capital seems closer to population wide education - a social activity not directly related to the knowledge on the frontier of science and technology as argued by Romer (1986). The contribution of education to economic development has mainly relied on cross-country estimates of gross enrolment rates or average years of schooling, which may be grossly inadequate if rates of return to investment in education or quality of education differ substantially across the countries. The weak correlation between growth and increases in educational attainment across the countries is observed by Benhabib and Spiegel (1994) and Pritchett (1997). Using panel data, Caselli et al. (1996) find a negative and significant correlation between output growth and secondary enrolment ratio. Knowles and Owen (1995) find education is not statistically significant in a range of models that include life expectancy and base period output per capita. In contrast to these findings, Barro and Sala-i-Martin (1995), Sala-i-Martin (1997), McMahon (1998), Temple (1999), Bils and Klenow (2000), Self et al. (2004) find schooling to be positively correlated with the growth rate of per capita Gross Domestic Product across countries. The differential outcome of education at the cross-country level is due to the existence of influential outliers and measurement errors of the model (Temple, 1999; Hojo, 2003). Most empirical research so far relies on rather traditional models of growth and development, which ignore some of the crucial aspects of the new growth models taking into account the dynamic feedback of the growth affecting variables. The indirect effect of education on economic growth is measured through productivity improvement. The productivity of labor is influenced by the investment in human capital. This line of thought has not only caused reawakening of the field of endogenous growth but has also established the significance of human resource development through the spillover benefits of education in achieving fast economic growth in many countries including the countries in Asia and Africa (McMahon, 1998; Brempong et al., 2004). Using the time series data, Haldar (2009) has observed that among the three growth models (viz. physical capital, human capital and export led growth), the human capital accumulation led growth model is more relevant to Indian economy.

3. Health Human Capital and Economic Growth

It is commonly believed that economic growth leads populations to live better, have longer lives and good health. Firstly, economic growth means rising per capita income and part of this increased income is translated into the consumption of higher quantity and better quality nutrients. Through nutrition, health as measured by life expectancy responds to increases in income (Fogel, 1997). Secondly, economic growth is fuelled by technological progress and part of this progress is reflected in improvements in medical science (Rosen, 1993; Morand, 2005). The state of health in a country affects its economic growth through various channels.[1] When health improves, the country can produce more

1. Good health and nutrition enhance workers' productivity. Healthier people who live longer have stronger incentives to invest in developing their skills, because they expect to reap the benefits of such investments over longer periods. Better health increases workforce productivity by reducing incapacity, debility and number of days lost due to sick leave. Moreover, good health helps to forge

output with any given combination of skills, physical capital and technological knowledge. One way to think about this effect is to treat health as another component of human capital[2] incorporated in formulating the endogenous growth models (Thomas et al., 1997, Bloom et al., 2001). The effects of human capital variables (namely, health and education) imply that the investment rate tends to increase as levels of education and socioeconomic status of health rise. Longer life expectancy encourages larger investments in human capital, which in turn accelerates the per capita income. The explanation of larger investments on human capital due to longer life expectancy is offered by Stark (1995) in terms of intergenerational transfer of assets. The provision of public resources for better health in a developing country can assist the poor to release resources for other investments, such as in education, as a means to escape poverty. The long-term relationship between income and health is examined by Arora (1999) considering the developed countries in the world and has observed the hypotheses that health of the population has influenced economic growth and that it should be an integral component of the productivity of economies and supporting the endogenous growth models. A similar study made by Arora (2001) provides that in the cointegrated relation between health and income, innovations in health lead to economic growth and not vice versa. Arora's findings is found to be similar to those reported by Fogel (1994; 1997) who has carried out a study on Western Economies over the past two centuries, from 1780 to 1979. In analyzing cross-country data over the past 25 years, Bloom and Sachs (1998) have obtained empirical evidence that health and demographic variables play an important role in determining economic growth rates. More recent studies have examined the effects of life expectancy on economic growth in the subsequent 15 to 25 years, which have consistently been found strong positive direct effects as well as indirect ones operating through rates of investment in physical capital or demographic profiles of the populations (Barro, 1997; Sachs and Warner, 1997; Bloom and Williamson, 1998). Bhargava et al. (2001) have assessed the effects of initial health status on growth over a shorter period of 5 years in a panel of countries and likewise found strong effects, but only in low-income countries. A series of macroeconomic cross-country studies have also found evidence for a significant impact of health (measured by life expectancy) on economic growth (Mayer-Foulkes, 2001; Caselli et al., 1996, Gallup and Sachs, 2000). The impact of health on income is an important policy issue that has motivated research at the World Health Organization. Mayer-Foulkes et al. (2001) has observed in the Mexican

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improved levels of education by increasing levels of schooling and scholastic performance (Schultz, 1997). Health affects economic growth through its impact on demographic factors. Shorter life expectancies inhibit investment in education and other forms of human capital, since there is greater risk that each individual will not survive long enough to benefit from investment. In addition, a larger proportion of the population which is dependent has a detrimental effect on rates of savings and capital investment and hence on subsequent growth (Kelly and Schmidt, 1996). Healthier workers are more productive for a variety of reasons – increased vigor, strength, attentiveness, stamina, creativity and so forth. Health and malnutrition reduce the physical capacity of the laborer, leading to lower productivity and resulting in lower wages (Zimmer et al., 2000).

2. Zon and Muysken (2005) argued that economic growth is driven by knowledge accumulation in the traditional Lucas Model (1988) and as such is based on on labor services supplied by healthy people. The health state of the population at the aggregate level (the share of healthy people in the population) determines the extent to which potential labor services embodied in the population can be used effectively. Moreover, knowledge accumulation requires the spending of 'healthy hours', wherein the embodiment of knowledge can take hold in individual people.

states that there has been a significant long-term impact (25-30 years) of life expectancy on economic growth. In the very recent period, the empirical validity of the theoretical model on income, health and health expenditure is examined in India by Haldar (2008) at the disaggregate level (state level) considering a longitudinal data for 26 years (from 1980-81 to 2005-06); both ways causality is examined between socio-economic status of health, income and health expenditure using Granger Causality tool and has found different types of results at the state level.

4. Progress of Income, Human Capital Investment and Human Capital Stocks in India

Growth in per capita GNP, public expenditure on education and health; and the outcome or attainment of human capital stocks measured by upper primary enrolment rate (up to class VIII), infant survival rate (ISR) and life expectancy at birth (LE0) are given in Table 1.

Table 1: Growth of per capita GNP, public expenditure on education & health, enrolment and infant survival rate (ISR)

Year	PCGNP	EE*	HE*	Enrl-VIII	ISR	LE_0
1960-61	4421.71	1.69	0.37	22.5	854	41.25
1970-71	5262.17	1.82	0.44	33.4	871	46.35
1980-81	5879.47	2.01	0.64	41.9	980	54.4
1990-91	7855.06	2.44	0.81	62.1	920	60.8
2000-01	11296.35	3.52	1.09	60.2	937	68**

Note: PCGNP=per capita GNP, EE* = education expenditure as a percentage of GNP, HE*= health expenditure as percentage of GNP, Enrl-VIII =Upper primary enrolment rate, ISR=infant survival rate, LE_0= Life expectancy at birth.
Source: GNP and PCGNP are at constant prices obtained from National Accounts Statistics, Government of India, educational statistics are drawn from Ministry of Human Resource Development; expenditure on health and Infant Survival Rate (ISR) are drawn from Ministry of Health and Family Welfare, Government of India, Life expectancy at birth (LE_o) is based on Census Reports, various issues except 2001. LE_0 for the year 2001 is estimated by expert group of population projection, Govt. of India.

Indian economy has been performing well after the 1980s. The average annual growth of real per capita GNP in the last four decades (viz.1961-71, 1971-81, 1981-91 and 1991-2001) were 1.9, 1.17, 3.36 and 4.38 respectively. This growth of GNP is not reflected consistently in the areas of social sector viz. education and health. From Table 1, it is found that the growth of real per capita GNP was higher during 1991-2001 compared to the earlier decades but the proportion of social sector investment, particularly in education and health was very low compared to other developing countries (UNDP, 2005). During the last 40 years, upper primary enrolment has increased only by 4.18 percent per annum. This shows that universalization of primary education (viz. 100 percent enrolment) still remains a distant dream. The magnitude of out-of-school children has been a stumbling block of achieving the universalization of primary education. Universalization of elementary education, a goal set by the Constitution to be achieved within a ten-year period after the Constitution was framed, still eludes and remains as the most conspicuous failure of the Indian education system (Tilak, 2006). The National Policy on Education of 1986 resolved that by 1995, all children would be provided free and compulsory education up to 14 years of age. Now, in 2001, the Union Government has revised this and announced that the universalization of elementary education with respect to enrolment and retention will be achieved by 2010.

In the years since independence, there have been significant gains in health status in India, but they do not compare favourably with those in many similarly placed developing countries. Life expectancy has gone up from 36 years in 1951 to 68 years in 2001. Infant mortality rate is down from 146 in 1951 to 63 in 2001. These gains have been made possible by the growth and development of health infrastructure and efforts to control communicable diseases such as immunization and improvements in determinants such as water supply and sanitation (Misra et al., 2003). But this gain in health status is too unsatisfactory compared to other developing countries. Life expectancy has increased by 64.84 percent during the last 40 years but it is still well below from many developing countries even from our neighboring country like Sri Lanka; Sri Lanka's life expectancy is 74.8 (UNDP, 2005).

The biggest impediment to analysis of health expenditure is the lack of any systematic compilation of national health accounts. In India, the dominant mode is private; private spending (i.e. out-of-pocket payments and voluntary insurance) contributes as much as 87 percent according to World Health Organization (2000). Poor public health expenditures remain the predominant cause of the unsatisfactory performance of the health system and it has been more or less remaining stagnant since 1951. India's public health expenditure was estimated at 0.9 percent of GDP, well below the average of 2.8 percent of low and middle-income countries, and the global average of 5.5 percent (World Bank, 2001a).

5. Theoretical Framework, Estimation Technique and Data

Endogenous growth theory as developed by Lucas (1988) basically represents an extension of the Solow (1956) neoclassical growth model incorporating positive externalities related to the accumulation of human capital viz. knowledge. Following Schultz (1997), Becker (1993) and Lucas (1988) it can be argued that the production of human capital is possible through education and health sector. The model used in this paper is derived from Lucas (1988) type endogenous growth model:

$$Y_i = A.F(\mu h L_i, K_i).H_a^{\gamma} \tag{1}$$

Where, A is the total factor productivity, Y_i is the output of the i^{th} firm, L_i is the number of workers used by firm i, μ is the proportion of time that each worker devotes to production, h is the human capital of worker employed by the firm i, K_i is the physical capital used by firm i. H_a is the average human capital in the economy and γ is a positive coefficient. Here, effective labor input $\mu h L_i$ replaces the simple labor input L, specified in the standard Solow (1956) growth model. H_a^{γ} term is the externality effect of human capital, which raises economy-wide labor productivity.

Broadly speaking, output in equation (1) is affected by physical capital and human capital. Now, how can we integrate the export led growth mechanism in equation (1)? At the aggregate level, open economy also considers export as a variable augmenting output, which is determined endogenously through labor productivity. In connection with this argument, Romer (1990) develops 'endogenous technical change' through research and development, as a human capital externality enabling the communication of knowledge inputs as well as facilitating the adaptation of new designs. Wood (1994) has claimed that skill development through education to be a key determinant of comparative advantage and manufacturing export performance. Thus, export led growth strategy is basically driven by endogenous growth.

Following McMahon (1998) and Oketch (2006), we consider the following implicit production function as:

$$\mathrm{Y_t}=\mathrm{Y}(\mathrm{K_t}, \mathrm{H_t}, \mathrm{N_t}) \tag{2}$$

Where, Y=aggregate output, K=stock of physical capital, H=stock of human capital and N=aggregate employment of the economy and t=time. Totally differentiating the reduced form of equation (2), with respect to time t and dividing through by Y, we have:

$$\frac{1}{\mathrm{Y}}\left(\frac{\delta Y}{\delta t}\right)=\frac{1}{\mathrm{Y}}\left(\frac{\delta Y}{\delta K}\right)\left(\frac{\delta K}{\delta t}\right)+\frac{1}{\mathrm{Y}}\left(\frac{\delta Y}{\delta N}\right)\left(\frac{\delta N}{\delta t}\right)+\frac{1}{\mathrm{Y}}\left(\frac{\delta Y}{\delta H}\right)\left(\frac{\delta H}{\delta t}\right)$$

$$\mathrm{y}=\mathrm{MPP_K}.\frac{\mathrm{I_K}}{\mathrm{Y}}+\mathrm{MPP_N}.\mathrm{n}.\frac{\mathrm{N}}{\mathrm{Y}}+\mathrm{MPP_H}.\frac{\mathrm{I_H}}{\mathrm{Y}} \tag{3}$$

Here, y and n represent rate of growth of output and employment respectively. $\mathrm{I_K}$ and $\mathrm{I_H}$ stand for investment in physical and human capital respectively. Assume that population grows at an exponential rate: $\mathrm{P_t}=\mathrm{P_0}.\mathrm{e}^{\mathrm{rt}}$, now we subtract the population growth rate r, from both sides of equation (3):

$\mathrm{y}-\mathrm{r}=\mathrm{MPP_K}.\frac{\mathrm{I_K}}{\mathrm{Y}}+\mathrm{MPP_N}.\mathrm{n}.\frac{\mathrm{N}}{\mathrm{Y}}+\mathrm{MPP_H}.\frac{\mathrm{I_H}}{\mathrm{Y}}-\mathrm{r}$, the left hand side represents the per capita growth rate of output: $\frac{\delta \frac{Y}{P}}{\delta t} \div \left[\frac{\mathrm{Y}}{\mathrm{P}}\right]$. Finally, we can write the above equation as follows assuming, $\theta=\frac{r}{n}$,

$$\mathrm{y}-\mathrm{r}=\mathrm{MPP_K}.\frac{\mathrm{I_K}}{\mathrm{Y}}+\mathrm{MPP_H}.\frac{\mathrm{I_H}}{\mathrm{Y}}-\mathrm{r}+\mathrm{n}.\left(\mathrm{MPP_N}-\theta.A\mathrm{PP_N}\right)/\mathrm{APP_N} \tag{4}$$

Assume the equality between r and n. This assumption is more valid and plausible in the developed western economies or may hold good in the planned economy but it is a restrictive assumption for the underdeveloped countries because of population growth rate which is higher than the growth rate of employment. The first and second term of right hand side of equation (4) is positive but the third term is negative. The coefficient of n is negative. This may be explained by considering a generalized Cobb-Douglas production function as:

$$\mathrm{Q}=\mathrm{A}.\mathrm{L}^{\mu_1}\mathrm{K}^{\mu_2}\mathrm{H}^{\mu_3} \tag{5}$$

where $0<\mu_1<1$. Since $\mathrm{MPP_N}=\mu_1.\mathrm{APP_N}$, equation (4) can be written as:

$$\mathrm{y}-\mathrm{r}=\mathrm{MPP_K}.\frac{\mathrm{I_K}}{\mathrm{Y}}+\mathrm{MPP_H}.\frac{\mathrm{I_H}}{\mathrm{Y}}+\mathrm{n}.(\mu_1-1) \tag{6}$$

Generally, in case of less developed economies, $\theta>1$ i.e., $r>n$, the magnitude of the coefficient of n is much more negative compared to the case, $\theta=1$. This is quite evident in case of the countries in Sub-Saharan Africa where the growth of population has been acting as a retarding factor of per capita growth of GNP.

One can decompose the I_K into two parts: public and private physical capital investment. Similarly, I_H can be decomposed into education and health both for public and private. Due to lack of such private long-term data on education and health expenditure, we only consider public spending on human capital (both for education and health). Since the annual data on employment growth rate (n) was not available for the entire period, we for the sake of simplicity ignore the effect of employment (as well as population) growth rate on per capita GNP for the sake of simplicity.

5.1 Estimation Technique

Now, treating output, investment in physical capital and human capital as endogenous, the following open-ended models are assumed for estimation as:

$$f(\ln PCGNP_t, PCIY_t, HCY_t, ENRLEgr_t \; \& \; D_{open})=0 \tag{7}$$

$$f(\ln PCGNP_t, PCIY_t, EDY_t, ENRLEgr_t \; \& \; D_{open})=0 \tag{8}$$

$$f(\ln PCGNP_t, PCIY_t, HELY_t, ENRLEgr_t \; \& \; D_{open})=0 \tag{9}$$

where,
lnPCGNP = Natual log of real per capita Gross National Product (GNP),
PCIY = Total (public and private) physical capital investment as a percentage of Gross Domestic Product (GDP),
HCY = Human capital expenditure (comprising education and health) as a percentage of GDP,
EDY = Education expenditure as a percentage of GDP,
HELY = Health expenditure as a percentage of GDP,
ENRLEgr = Growth of Gross Enrolment of Class VIII,
Dopen = Dummy Variable for openess[3] = 1 after 1991 and 0 otherwise.

In order to avoid the problem of the specification arising from simultaneity (endogeneity) and to investigate the long-run linkages among the four variables mentioned in equations (7), (8) and (9), we use the cointegration methodology as developed by Johansen (1988) and Johansen and Juselius (1990). Given the endogeneity property among the variables, it would be better and appropriate to employ the Johansen's multivariate cointegration approach, where all variables in the VAR system are assumed to be dynamically related.

The stock of human capital is divided into two parts: education human capital and health human capital. From the above analysis, the education human capital stock can be measured but the problem arises in measuring the stock of health human capital over time. Health is an unobservable variable and its stock at the individual level continuously decreases. However, the health stock, for the time being can be augmented by proper medical treatment. But at the macro-level, over time the health stock can be measured by

3. The Government of India has opened its market in 1991 and from that year the structural adjustment programme has been going on.

life expectancy, infant survival rate, morbidity prevalence rate, disability adjusted life years etc. Incorporating this idea and following Thomas et al. (1997), Bloom et al., (2001), we could incorporate health stock measured by ISR in our model but it does not appear to have any significant relationship with the variables under study. This is quite surprising in our analysis. ENRLE represents upper primary (class V to class VIII) enrolment ratio measured as education human capital stock. We could incorporate the lower primary enrolment ratio in our model but upper primary enrolment ratio is expected to provide a good measure of educational stock since it is less fluctuating and its value throughout the period is less than 100 compared to lower primary enrolment ratio. It is to be mentioned here that the higher enrolment data are unavailable for the entire time period.

Most of the empirical works on endogenous growth consider the output of education human capital measured by enrolment[4]. Our model helps to understand the effect of education stock on economic growth in presence of human capital expenditure, which is assumed to be distinct from earlier empirical growth models.

The essence of Johansen's cointegrating relationship is that the variables in the system share a common unit root process, this approach is appealing because it treats all the variables as endogenous; it thus avoids the arbitrary choice of the dependent variable in the cointegrating equations but it is more applicable in case of large samples. Following Pesaren and Shin (1995), one can use the Auto-Regressive Distributed Lag (ARDL) approach of cointegration which does not involve pre-testing variables, which means that the test on the existing relationship between variables in levels is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1) or a mixture of both.

5.2 Data

We analyze the above open-ended models represented by equation (7), (8) and (9) using annual data from 1960 to 2005. The data sets of the variables like GNP, total investment (i.e., public and private) of physical capital are drawn from Planning Commission, National Accounts Statistics, Government of India. Data on education expenditure and enrolment are drawn from the Ministry of Human Resource Development, Government of India whereas data on health expenditure and infant survival rate are derived from the Ministry of Health and Family Welfare, Government of India. We have used Microfit 4.1 and Eviews 6.0 softwares for the econometric analysis.

6. Results and Discussion

Table 2 shows the summary statistics of the variables understudy. Mean growth of all the variables are ranging from 1.76% for PCIY to 2.96 % for ENRLE. Year eight enrolment is growing at much faster rate than other variables under study. It is also clear from the table that the volatility of the investment on education and health are much higher than other variables,

4. Barro and Sala-i- Martin (1995), McMahon (1998) and Mallick (2002) have used school enrolment rates in measuring the stock of human capital in the endogenous growth model.

Table 2: Summary Statistics

	GNPgr	ENRLEgr	EDYgr	PCIYgr	HCYgr	HELYgr
Mean	2.43	2.96	2.16	1.76	2.01	2.54
Std. Dev.	1.66	3.72	4.84	4.27	4.66	5.19
Skewness	-0.29	0.79	-0.30	-0.17	0.08	0.88
Kurtosis	2.22	4.60	2.83	3.24	3.32	5.93
JB Normality test	1.75 (0.42)	11.34 (0.00)	0.72 (0.70)	0.32 (0.85)	0.24 (0.88)	21.85 (0.00)
Number of observations	45	54	45	45	45	45

Note: p-values in bracket. ENRLE is from 1950-51.

which is not a good sign for long-term development in social sector in India. Health and education investment should be consistent, which in turn, may increase the overall growth of the country through human capital formation.

Before examining the Johansen's cointegration technique, all the variables are to be tested for stationarity as a prerequisite. At the elementary level, stationarity can be tested plotting the correlogram of a time series but at the formal level, this can be examined by finding out if a time series contains a unit root. The stationarity of the data set is examined using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwialkowski-Phillps-Schmidt-Shin (KPSS) tests. Unit root test results are given in Table 3.

Table 3: Unit Root test

Different Unit Root Tests						
Variables (in levels & first difference)	ADF		PP		KPSS	
	C	C & T	C	C & T	C	C & T
lnPCGNP	3.29 (2)	0.11 (2)	4.43 (3)	0.50 (3)	1.19 (3)	0.31 (3)

ΔlnPCGNP	-2.89*** (2)	-6.06* (2)	-2.69*** (3)	-4.09** (3)	0.82 (3)	0.10* (3)
PCIY	0.35 (1)	-2.52 (1)	0.55 (3)	-2.20 (3)	1.23 (3)	0.09* (3)
ΔPCIY	-5.74* (1)	-5.81* (1)	-6.09* (3)	-6.16* (3)	0.14* (3)	0.08* (3)
HCY	0.83 (1)	-1.64 (1)	0.99 (3)	-1.33 (3)	1.12 (3)	0.22 (3)
ΔHCY	-3.96* (1)	-4.36* (1)	-5.23* (3)	-5.50* (3)	0.26* (3)	0.05* (3)
EDY	2.22 (1)	0.07 (1)	2.96 (3)	0.57 (3)	1.32 (2)	0.29 (2)
ΔEDY	-3.35** (1)	-4.45* (1)	-4.64* (3)	-5.49* (3)	0.59** (2)	0.12** (2)
HELY	0.52 (2)	-3.29** (2)	0.58 (3)	-3.01 (3)	1.22 (3)	0.10* (3)
ΔHELY	-4.44* (2)	-4.42* (2)	-5.73* (3)	-5.79* (3)	0.13* (3)	0.05* (3)
ENRLE	-1.07 (1)	-2.48 (1)	-0.98 (3)	-1.91 (3)	1.43 (3)	0.10* (3)
ΔENRLE	-4.21* (1)	-4.25* (1)	-4.65* (3)	-4.65* (3)	0.09* (3)	0.06* (3)

Note: *, ** and *** implies significant at 1%, 5% and 10% level respectively. Number within parentheses represents optimum lag determined from AIC Criterion.

It is clear from Table 3 that all variables under study have unit root, or non-stationary or integrated of order one in its level and stationary, or integrated of order zero at its first difference at least at 5% level. Hence all the series are non-stationary and the standard regression analysis may produce spurious results. Once the series are made stationary, they can be used in regression analysis. But the drawback of this method is the possibility of losing long-run information about the variables. This problem can be overcome by applying the cointegration technique, which shows the long-run equilibrium relationship between two or more non-stationary series. The variables are said to be cointegrated if they are integrated of order one. To find out the number of cointegrating vectors we have applied maximum likelihood-based λ-max and λ-trace statistics introduced by Johansen (1988; 1992) and Johansen and Juselius (1990). In a set of m series, if there are 'r' co integrating vectors, then there are (m-r) common stochastic trends. Prior to testing the number of significant vectors we have tested the optimal lag length using the likelihood ratio (LR), AIC and SBC criteria. The Johansen ML procedure is applied to the VAR formed by the non-stationary variables along with two exogenous variables in each of equation (7), (8) and (9). The results of Johansen's test and the normalized cointegrating vectors are presented in Table 4. Based on the λ-max and λ-trace statistics from Table 4 we can conclude that there exists at least one cointegrating vector for three different relations mentioned in equations (7), (8) and (9).The normalized cointegrating vectors in the co integrating relations are given at the bottom of the λ-max and λ-trace statistics in Table 4. Next we test the significance of each variable in the cointegrating relation by using the LR test statistics given by Johansen, which is asymptotically chi-square with one degree of freedom. The variables that are statistically significant can contribute to the long run relationship. From first panel of Table 4, we observe that lnPCGNP, PCIY and HCY are cointegrated with one cointegrated vector. Similarly, EDY and HELY are also cointegrated with lnPCGNP and PCIY separately at least at 1% level. In all the cases, the eigenvalue statistics drop sharply for alternative hypothesis of third cointegrating vector. Thus, we can conclude that our model with three variables is a fair representation for all three equations.

It can also can be observed from the second part of each panel that, PCIY did not influence lnPCGNP significantly, but HCIY, EDY and HELY influence the per-capita GNP positively and significantly.

Table 4: Johansen's Cointegration Test
Cointegration LR test based on maximum eigenvalue of the stochastic matrix

	Hypothesis	Alternative	Eigen-value	λ -max	λ -Trace
Variables under study: lnPCGNP, PCIY, HCY & ENRLEgr, Dopen					
VAR(3)	r = 0	r =1	0.8402	27.48*	49.77*
	r ≤ 1	r =2	0.3312	16.92	22.29
	r ≤ 2	r =3	0.1200	5.37	5.37
LR estimates	***lnPCGNP= - 0.0129 PCIY + 0.3137* HCY + 0.0126*** t*** ***(-0.68) (4.19) (1.91)***				
Variables under study: lnRPCGNP, PCIY, EDY & ENRLEgr, Dopen					
VAR(2)	r = 0	r =1	0.4516	25.24***	43.11*
	r ≤ 1	r =2	0.2918	14.49	17.87
	r ≤ 2	r =3	0.0773	3.38	3.38
LR estimates	***lnPCGNP= - 0.0040 PCIY + 0.2712* HCY + 0.0200*** t*** ***(-0.17) (2.81) (1.92)***				
Variables under study: lnPCGNP, PCIY, HELY & ENRLEgr, Dopen					
VAR(3)	r = 0	r =1	0.5579	34.32*	61.86*
	r ≤ 1	r =2	0.3478	17.93***	27.54**
	r ≤ 2	r =3	0.2035	9.61	9.61
LR estimates	***lnPCGNP= - 0.0778***PCIY + 4.2678* HELY + 0.0221 t*** ***(-1.92) (2.56) (1.02)***				

Notes: i) *, ** and *** indicate significant at 1%, 5% and 10% levels respectively
ii) Figures in parenthesis represent the t-statistics.

Since lnPCGNP, PCIY and HCY (or EDY or HELY) are found to be cointegrated, we proceed to test their error correction mechanism. Table 5 presents the results of the error correction models for all three models (represented by equations 7, 8, and 9) of real per capita GNP growth (viz. ΔlnPCGNP). The estimated co-efficients show the immediate impact of ΔPCIY and ΔHCY (or ΔEDY or ΔHELY) on ΔlnPCGNP. It also shows the lag effect of three years of year eight enrolment growth and openness. The short-run adjustment coefficient i.e., error correction (ECM) terms of equations (7), (8) and (9) appear to be significant at 5%, 1% and 10% respectively. The ECMs terms of equation (7) and (8) give us that about 7% of the deviation of actual growth of GNP from its long-run equilibrium level is corrected each year whereas it is only 2% for equation (9). The short run coefficients of ΔPCIY are found to be insignificant for all three equations suggesting that PCIY has no effect on the growth of per capita GNP. The short-run relationship between different types of investment expenditure and per capita GNP growth are mostly negative and insignificant for most of the cases. However, third lag of year eight enrolment growth and openness dummy is positive and significant at 1% level for all three equations. The results indicate that enrolment growth before three years significantly enhancing per capita GNP growth. It also shows that the growth has been increased significantly after liberalization of the Indian economy. The findings are very important especially for the policy perspective.

Table 5: Short-run relationships of the variables estimated using cointegrating VAR

Dependent variable GNPgr			
Independent variable	Equation 7	Equation 8	Equation 9
Constant	0.566** (2.31)	0.584* (3.38)	0.238*** (1.83)
$GNPgr_{t-1}$	0.507* (3.38)	0.568* (3.81)	0.687* (4.13)
$GNPgr_{t-2}$	-0.008 (-0.04)	-0.021*** (-1.89)	-0.138 (-0.70)
$GNPgr_{t-3}$	-0.001 (-0.67)	-0.390** (-2.61)	-0.278*** (-1.70)
$PCIYgr_{t-1}$	-0.001 (-0.40)	-0.001 (-0.45)	0.001 (0.01)
$PCIYgr_{t-2}$	0.005 (0.21)	-0.0003 (-0.16)	0.003 (0.13)
$PCIYgr_{t-3}$	-0.001 (-0.67)	-0.002 (-0.89)	-0.001 (-0.49)
$HCYgr_{t-1}$	-0.002 (-1.50)	-----	------

$HCYgr_{t-2}$	-0.012 (-0.79)	-----	-----
$HCYgr_{t-3}$	-0.031*** (-1.85)	-----	-----
$EDYgr_{t-1}$	-----	-0.033*** (-1.89)	-----
$EDYgr_{t-2}$	-----	-0.008 (-0.44)	-----
$EDYgr_{t-3}$	-----	-0.031*** (-1.76)	-----
$HELYgr_{t-1}$	-----	-----	-0.127 (-1.65)
$HELYgr_{t-2}$	-----	-----	-0.036 (0.47)
$HELYgr_{t-3}$	-----	-----	-0.187** (-2.40)
ECM_{t-1}	-0.070** (-2.27)	-0.072* (-3.33)	-0.028*** (-1.75)
$ENRLEgr_{t-3}$	0.001* (2.74)	0.001* (2.71)	0.001 (1.44)
Dopen	0.022* (3.88)	0.022* (4.04)	0.018* (3.18)
$\overline{R}^2$	0.61	0.67	0.61
DW	1.74	1.76	1.67
SC	2.22 (0.14)	1.62 (0.20)	3.56 (0.06)
FF	4.05 (0.04)	3.42 (0.06)	1.54 (0.22)
NORM	1.03 (0.60)	1.86 (0.40)	0.15 (0.93)
HET	1.02 (0.31)	1.11 (0.29)	0.81 (0.37)
Where, GNPgr=ΔlnPCGNP; PCIYgr=ΔPCIY; EDYgr=ΔEDY and HELYgr=ΔHELY			

Notes: i) *, ** and *** indicate significant at 1%, 5% and 10% levels respectively
ii) Figures in parenthesis represent the t-statistics.

Generalised Impulse Response Analysis

In this section we further investigate the statistical significance of innovations of the variables under study by using Generalised Impulse Response Functions (GIRF), introduced by Pesaren and Shin (1998). We have estimated GIRF by employing VAR, consisting of ΔPCIY, ΔEDY, ΔHELY and ΔlnPCGNP. The number of lags is determined by AIC. The impulse response results are presented in Appendix (Figure 1). Dashed lines indicate two standard error bands representing a 95% confidence region.

Figure 1 shows that the innovation in per capita GNP growth can only explain the movements of ΔEDY and ΔlnPCGNP positively and significantly and the effect lasts for less than three years, but, does not explain the movement of ΔPCIY and ΔHELY. Similarly, the innovation in ΔEDY significantly and positively explains the movements of ΔEDY (itself) for a short period of time. On the other hand the innovations of ΔHELY explain the movements of per-capita education growth and ΔHELY significantly and positively.

7. Conclusion

This study makes an effort to establish a relationship among physical capital investment, investment in education and health on per capita GNP growth using annual data for India. We found that investment in education and health are very important and has a significant positive long run effect on per capita GNP growth. We have also found that the year eight enrolment has positive and significant effect on GNP growth after three years. India has opened its economy in 1991 and the growth has significantly increased after that period. The results are further explained by the Generalised Impulse Response Analysis.

One can conjecture a number of factors. Good health and nutrition enhance workers' productivity. Healthier people who live longer have stronger incentives to invest in developing their skills, which increases workforce productivity by reducing incapacity, debility, and number of days lost to sick leave. Our findings are supported by Schultz's (1997) study where he mentioned about scholastic performance. Zon and Muysken (2005) argued that economic growth is driven by knowledge accumulation in the traditional Lucas Model (1988) and as such is based on labour services supplied by healthy people.

Obviously, investment on health and education work differently for different countries, but it is a fact that for India's health and education i.e., overall human capital expenditure has definitely long run impact on growth. Unfortunately the expenditure on such an important area is not consistently supported by the Government of India. In fact the expenditure on human development is inconsistent and severely inadequate. Public expenditure on education and health is an important policy instrument for realizing social sector development. The Government of India has initiated various policies and programmes in this direction since independence but the progress of human capital in India is very slow compared to many developing countries.

Recognizing the contribution of education to economic development and keeping in line with the human capital investment revolution in economic thought, the Government of India has accepted the concept of 'investment' in education in its 1968 Policy and fixed a target of six percent of national income to be invested on education by 1986. The proportion of GNP invested in education was 3.8 percent in 2005-06. Compared to the very low level of 0.6 percent in 1951-52, this marks a very significant progress but still it is well below the average of many developing countries in the world.

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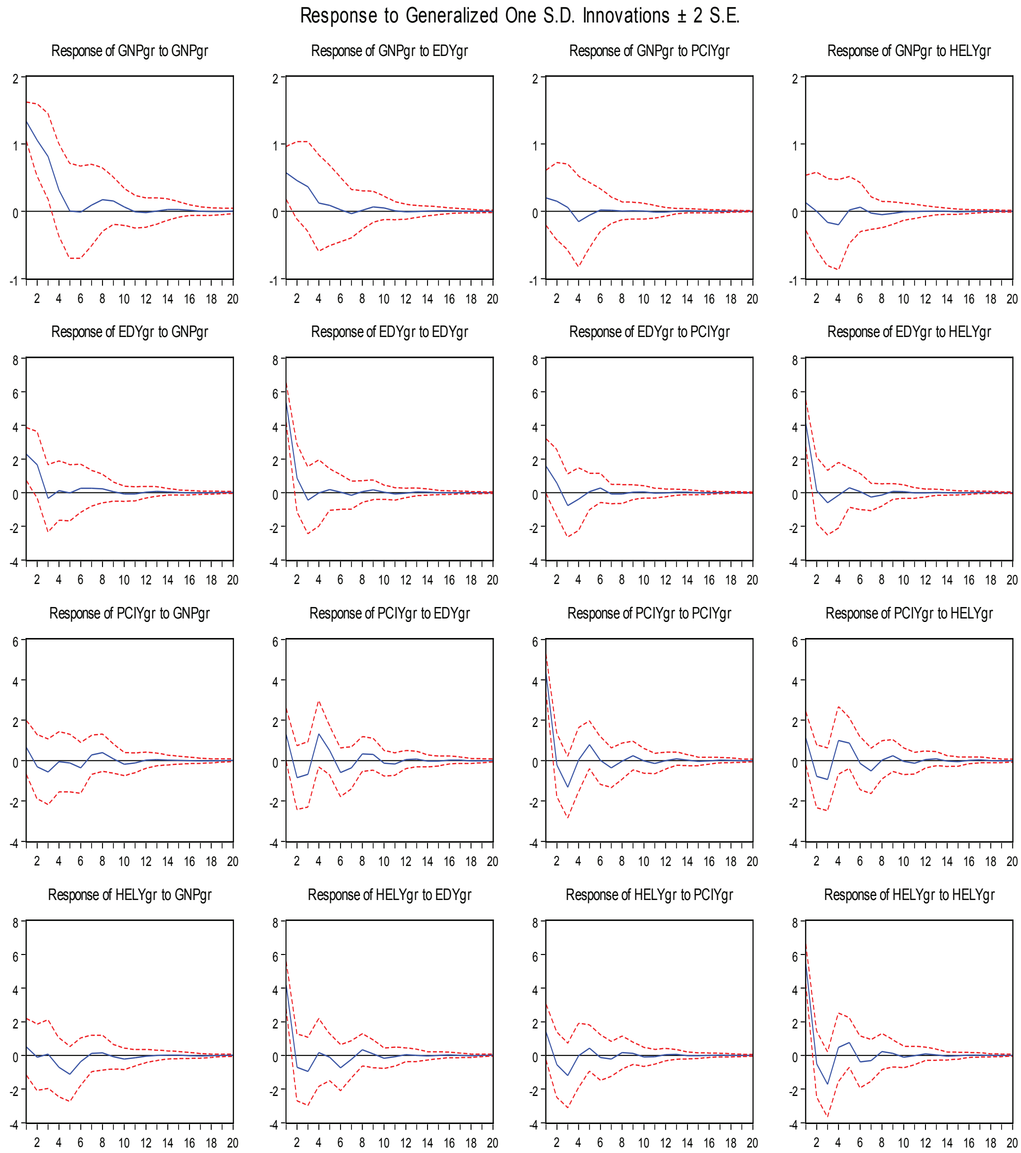
Appendix

Figure 1: Impulse Response Function



Where, GNPgr=ΔlnPCGNP; PCIYgr=ΔPCIY; EDYgr=ΔEDY and HELYgr=ΔHELY